HIGH SPEED/HIGH DENSITY OPTICAL STORAGE SYSTEM USING ONE-DIMENSIONAL MULTI-FUNCTION/MULTIPLE PROBE COLUMNS

BACKGROUND OF THE INVENTION

Field of the Invention:

The invention relates generally to a high speed/high density optical storage system using one-dimensional multi-function/multiple probe columns, and more particularly to, a high speed/high density optical storage system using one-dimensional multi-function/multiple probe columns capable of recording/reading high density data at high speed on a disk type recording medium using a multiple/multi-function near-field optical probe technology.

Description of the Prior Art:

Today, a commercial technology of recording data on an optical disk such as CD or DVD records/reads data by focusing a laser light at a fine focus of about 1μ m while scanning a single optical head on a rotating optical disk. Thus, in order to obtain the data recording density required in a high resolution TV or an internet broadcasting, etc. which would be commercialized in the future, it is required that small recording/reading bit size of about several dozens of nm be implemented. In case of focusing laser using current optics, however, there is a physical limitation that the bit size smaller than the wavelength of used light could not be implemented due to diffraction of light. Therefore, in order to solve this problem, there recently been introduced a near-field optical data storage technology. The near-field optical data storage technology does not

focus light using the lens but flows light into the probe having small apertures while controlling an atomic force between the probe and the media, so that recording bits smaller than the wavelength of light can be recorded/read with the probe in several dozens of nm from the surface of the media. The near-field optical data storage technology is based on the following principle: if light is flowed into the probe having small apertures at the end with the probes within several dozens of nm from the surface of the media, a light source much smaller than the wavelength of light is produced. This technology has been actively researched as a next-generation large-capacity optical data storage system since it can implement recording bit size of several dozens of nm. Meanwhile, as one similar to the above technology, it was reported that high density data recording of ~Tbi/in^2 can be implemented by means of a method by which heat or an electric field is applied at a local position on a recording medium using a cantilever type probe of an atomic microscope. The data storage system using a scanning type probe employing this near-field optics or the atomic gap force, however, has a technical difficulty that the distance between the probe and the recording medium must be constantly maintained below several dozens of nm.

Generally, the data storage system using a scanning type probe measures the atomic gap force between the probe and the recording medium to control the gap using a signal from a feedback circuit. However, this method has the possibility that it will wears out the probe and data transfer rate is limited because the bandwidth of an electric circuit for controlling the gap limits the scanning speed of the media. Another problem is that the optical transmittance of the near-field probe is generally small below 10^{-3}, it becomes another factor to degrade the recording rate because it requires a certain period of time to cause phase change on the recording medium when light is used. Therefore, in order to increase the recording/reading speed, a plurality of probes are generally

employed to increase the data transfer rate. Of course, as data is dividedly recorded using the plurality of the probes, the data transfer rate can be increased in principle as the number of the probe.

Multi-probe data storage system, currently have been researched, uses two-dimensional probe column of a matrix shape [Binning et al. Appl. Phys. Lett. V. 74 1329-1331 (1999)]. However, this system has a difficulty in applying a rotation type disk, which is the most efficient media scanning method. And as the probe directly contacts the media when data is recorded/read, the system may cause error due to wear-out of the probe or vibration when data is recorded/read.

In order to raise the data transfer rate of the near-field optical data storage system to the degree of commercialization, the optical probe must be multiplied. To multiply an optical head using a light focusing method by the lens being an existing method was already proposed [U.S. Patent No. 4,972,396 issued to David J. Rafner, etc.]. In the patent, as each of the optical heads is independently controlled, they can record and read data at the same time. Therefore, this patent is effective in performing multiple tasks and can thus increase the data transfer rate. Recently, there has been proposed a multi-beam optical recording/reading method using a two-dimensional plan array of semiconductor laser, vertical surface emitting laser [U.S. Patent No, 5,808,986 issued to Jack L. Jewell, etc.]. An example of multiplying the near-field optical probe could be seen from a prior art [U.S. Patent No. 6,101,165 issued to Motonobu Korogi, etc.]. This prior art can increase the data reading speed using two-dimensional matrix type probe column. These patents proposed a technology by which a contact pad at the edge of the near-field optical probe column of a plan array shape contacts the media to read recorded bits while scanning the disk. In this case, the gap between the probe and the media is controlled by the force physically pushing the probe column. Thus, a high

speed scanning on the media can be achieved, which results in an increase of the data transfer rate. However, as the optical efficiency of the near-field optical probe is low (below 10^{-3}), it is still a severe problem upon recording of data.

Because the optical recording speed is directly proportional to the amount of light illuminated. Therefore, additional recording mechanism other than photon mode recording is necessarily required for a high-speed recording.

SUMMARY OF THE INVENTION

In order to solve the stated problems, a high speed/high density optical storage system using one-dimensional multi-function/multiple probe column according to the present invention is to provide a technology capable of selecting a recording mode using an electric field or heat as well as light when data is recorded, by integrating optical probes in one column in a radial direction of a media so that a conventional rotation type optical disk technology can be intact used and by selectively operating a cantilever type or a contact pad type for controlling the optical probes to contact the probes on the surface of the media always or intermittently.

In order to accomplish the above object, an optical data storage system capable of recording/reading optical data on a disk media is characterized in that it comprises multiple probe columns arranged in a row, wherein a region on which data can be recorded on the disk media which is divided into small tracks and large tracks, and the probe column between the small tracks and the large tracks is moved by a dual driving control device in which high resolution movement and low resolution movement are integrated.

An optical data storage system according to the present invention comprising: a disk media having small tracks and large tracks, a probe column

driving arm; multiple probes arranged in a row, with the probes being attached to a free end of the probe column driving arm and moving in a radial direction of the disk media; and a dual driving control device to move the probes, with the dual driving control device having a high resolution transferring device capable of moving between the small tracks and a low resolution transferring device capable of moving between the large tracks.

Preferably, the probe includes a plurality of optical probes and AFM probes, the AFM probes record data using heat/electricity and control a gap between the disk media, and the optical probes record/read data using light.

Also, an optical data storage method capable of recording /reading optical data on a disk media is characterized in that a plurality of probes for recording/reading data are arranged in a row, wherein a column of the probes between small tracks on a media disk is moved by a transducer having a high resolution and a column of the probes between large tracks on the media disk are moved by a transducer having a low resolution.

BRIEF DESCRIPTION OF THE DRAWINGS

The aforementioned aspects and other features of the present invention will be explained in the following description, taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a perspective view of a multi-function/multiple probe column according to one embodiment of the present invention, wherein the probe is controlled by a dual driving device on a disk media to record/read data;

Fig. 2 shows a state that multiple probe columns move spirally fine tracks on the media disk to record/read data;

Fig. 3 is a construction showing a single type probe to which a contact pad

is attached according to one embodiment of the present invention; and

Fig. 4 is a construction showing a complex type probe where cantilever style gap control is implemented.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

A high speed/high density optical storage system using one-dimensional multi-function/multiple probe column according to a preferred embodiment of the present invention will be described in detail with reference to accompanying drawings.

Fig. 1 is a perspective view of the multi-function/multiple probe column according to the present invention, wherein the probe is controlled by a dual driving device on a disk media to record/read data.

Referring now to Fig. 1, the optical storage system according to the present invention includes a plurality of probes **10**, optical illuminating inlets **16**, a dual driving control device **21**, a probe column driving arm **22**, a recording/reading disk media **30** and recording/reading bits **34**.

The probes **10** have an exterior shape in which the probes **10** are arranged in one column. Each of the probes **10** is attached to a free end of the arm **22**. The arm **22** is moved in a radial direction to the media disk **30** and records/reads data while the disk **30** is rotated. Each of the probes **10** has a light source and an optical detector and is independently controlled. It should be understood that the probes **10** can be made using electrical/thermal conductive materials or can have its surface coated with conductive materials to have electrical/thermal conductivity.

Fig. 2 shows a state that multiple probe columns move spirally fine tracks on the media disk to record/read data.

A mode of recording/reading data on tracks may include both a spiral

mode and a concentric circle mode of CD or DVD, which have been presently commercialized. All data is divided to have the same amount to the number of the probes **10**, so that the same amount of data can be simultaneously transmitted to respective probes **10**. Data recording region on the disk **30** is divided into small tracks **33-35** and large tracks **31** and **32**. The small tracks **33-35** indicate fine tracks being the minimum unit for recording/reading data. The large tracks **31** and **32** indicate tracks having a size similar to the width of the probes **10** column. For example, if the width of the probes **10** column (distance from the first probe to the last probe) is 1mm and the radius of a face of the disk **30** on which data can be recorded is 10mm, it means that there are **10** large tracks **31** and **32**. As the distance between all the probes **10** is constant, a region for which respective probes **10** are responsible for recording and reading is up to the first track in an immediately neighboring probe **10**. If the distance between the probes **10** is 50μm and the distance between the tracks 50nm, it means that there are 1000 small tracks **33-35** between the probes **10**. If all the small tracks **33-35** existing between the probes **10** are completely scanned, the probe **10** column should be moved in a radial direction of the disk **30** by the length to the probe **10** column.

Therefore, in order to record/read data on the small tracks **33-35** between the probes **10**, it is required that a transducer having a high resolution of several nm be provided. In order to move between the large tracks **31** and **32**, a long distance transducer having a low resolution but capable of moving several mm is required. In other words, a dual transducer is required. As the high resolution transducer has a short moving range of several tens of μm but has a resolution of several nm, it is suitable for control using piezoelectric materials. The low resolution transducer uses a driving device of a conventional optical data storage system such as a voice coil. The weight and size of the optical head that focuses

light to and collects light from the probe array is minimized through MEMS (micro-electronic mechanical system) technology. When the probe **10** is used to control a signal and to record data, the recording/reading frequencies of each of the probes **10** are designed to be same for the purpose of the efficiency of integration upon distribution and data reproduction. As the scanning speed between the probe **10** located inmost the probe **10** column and the probes **10** located outmost the probe **10** column is different, the outermost track has a greater distance between the bits than the inmost track. Thus, there is some possibility that the recording/reading data density may be degraded. However, an effect on the recording/reading density can be minimized by designing the length of the probe **10** column to be small compared to the size of the disk. For example, assuming that the distance between the probes **10** is $50\mu m$ and the number of the probes **10** is 20, the distance between the inmost probe and the outermost probe is about 1mm. Therefore, as degradation of the recording density by the outermost probe in a large track having the radius of 10mm is about 10%, an effect on the entire recording density is very few.

Fig. 3 is a construction showing a single type probe to which a contact pad is attached according to one embodiment of the present invention.

As can be seen from Fig.3, an optical aperture **16** having a several dozens of nm in size is located at an end of the probes **10**. The probes **10** may be manufactured using electrical/thermal conductive materials or may have its surface coated with conductive materials to have electrical/thermal conductivity. When data is read, recorded data is read at high speed by scanning the light through the probe **10** on the media **30**. When data is recorded, data is recorded by controlling the cantilever **11** to apply electricity or heat to the media **30**. Each of the probes **10** is manufactured on the AFM (atomic force microscopy) type cantilever **11** made of piezoelectric materials and a vertical position of the

probes **10** can be also adjusted by detecting the atomic gap force. Therefore, each of the probes **10** can be independently controlled to contact the media **30** when electricity or heat is transmitted to the media **30**. The atomic gap force between the probes **10** and the media **30** can be measured, by sensing an electric signal generated in proportion to the deflection of the cantilever **11** or reflecting a laser light using a conventional deflection detection scheme of AFM cantilever.

Fig. 4 is a construction showing a complex type probe where cantilever style gap control is implemented. The complex type probe according to the present invention includes an optical probe **14** having an aperture **16**, and a AFM probe **15** having no aperture, both of which form a single cantilever **11**. The AFM probe **15** may be made using electrical/thermal conductive materials or have its surface coated. The difference in the length between both the probes **14** and **15** must be below several dozens of nm. Therefore, the AFM probe **15** can maintain the spatial resolution of the optical probe **14** when it contacts the surface of the media **30** by allowing the optical probe **14** to be located at the near-field region. As the cantilever **11** is coated with piezoelectric materials, the vertical position of the cantilever **11** can be electrically controlled. Or the gap can be controlled, by reflecting laser light off the cantilever **11** and reading the deflection of the cantilever **11** and measuring the atomic force. The AFM probe **15** controls the gap and uses heat/electricity to record data. The optical probe **14** is responsible for recording/reading data using light. This type of structural characteristic can minimize the size of recording bits since the topographic resolution of the AFM probe **15** having no optical aperture is better than the optical probe **14**. Also, as the AFM probe **15** is responsible for the gap control, this type of structural characteristic can maintain the resolution of the optical probe **14** since the optical probe **14** is not worn out due to repetitive data reproduction.

As can be seen from the description, a high speed/high density optical storage system using one-dimensional multi-function/multiple probe column according to the present invention has an advantage that it can be used with rotating disk media in recording/reading data in excess of the diffraction limit of light by recording/reading data using the probes. The present invention can significantly increase the data recording speed using multi-function probes capable of applying electricity or heat and illuminating light. According to the present invention, as various recording mechanism other than optical recording can be adopted, the type of-media can be easily selected. Also, as several probes can simultaneously record/read using multi-probe array, data transfer rate can be increased by the number of the probes over using a single probe.

The present invention has been described with reference to a particular embodiment in connection with a particular application. Those having ordinary skill in the art and access to the teachings of the present invention will recognize additional modifications and applications within the scope thereof.

It is therefore intended by the appended claims to cover any and all such applications, modifications, and embodiments within the scope of the present invention.